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EFFECTS OF FIRE AND GROUNDWATER EXTRACTION ON ALKALI MEADOW HABITAT IN OWENS VALLEY, CALIFORNIA

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ABSTRACT

Alkali meadow habitat—a groundwater dependent ecosystem—is rare in California, and its response to fire has not been documented. We sampled vegetation in this habitat across a pumping-induced depth-to-water (DTW) gradient immediately before, then eight weeks after, a summer wildfire. After the fire in the burned area, we documented vigorous re-growth of native perennial grasses in areas of shallow groundwater but no re-growth of shrubs. The dominant grass *Sporobolus airoides* flowered in the shallow end of the DTW gradient but never advanced beyond vegetative phenology (leaves) in the drawn-down end. DTW explained 77% of the grass cover variance in the post-fire burned area, and 87% and 94% of the grass cover variance in the pre-fire and post-fire unburned (control) areas, respectively. This suggests that post-fire re-growth was re-establishing a cover-DTW relationship already present before the fire. The principal short-term fire effect was the elimination of shrub cover due to apparent shrub mortality. Our study shows fire may be an effective management tool for regenerating alkali meadow in areas of shallow groundwater. However, in areas subject to long-term water table drawdowns we found negligible grass re-growth and increased vulnerability to erosion, suggesting fire may accelerate the process of type-conversion from meadow to xeric shrubland.

Key Words: *Distichlis spicata*, fire, groundwater-dependent, groundwater pumping, habitat loss, *Sporobolus airoides*, vegetation change, water table.

On July 6, 2007, lightning strikes along the base of the eastern escarpment of the Sierra Nevada in Owens Valley, California, started several fires. They became known as the Inyo Complex fire as they coalesced and burned >14,000 ha, almost destroying the towns of Independence and Big Pine. The fires started in sagebrush/bitterbrush shrubland high on alluvial fans and were blown by strong winds downslope through Mojave Desert shrubland to burn alkali meadow habitat at the fan toes.

Re-growth after the fire varied considerably in the alkali meadow. In some areas we observed native perennial C_4 grasses, *Sporobolus airoides* (alkali sacaton) and *Distichlis spicata* (saltgrass, nomenclature follows Baldwin et al. 2002), re-sprouting within days after the fire. In other areas we saw no re-growth. After several weeks, grass re-growth was so robust in some areas it was difficult to tell that a fire had occurred.

Alkali meadow habitat is rare in California (Sawyer and Keeler-Wolf 1995), and there are few quantitative data regarding its response to fire. Anecdotal observations made after other recent Owens Valley fires suggest *S. airoides* and *D. spicata* recover rapidly in areas of shallow groundwater, but we had not had the opportunity to closely monitor recovery after fires in areas subject to groundwater drawdowns. Understanding the response of alkali meadow to fire in areas of lowered water table is important because drawn-down water tables underlie much of this habitat in Owens Valley. The Inyo Complex fire burned a portion of alkali meadow habitat which covered a large gradient in depth-to-water table (DTW) at the time of the fire. It thus offered an unplanned opportunity to observe alkali meadow response to fire in areas of both shallow and deeply drawn-down groundwater.

Our primary objectives were to: 1) document species composition, cover, frequency, and phenology of the observed post-fire growth throughout the burned portion of the study area; 2) compare characteristics of pre- and post-fire vegetation; and 3) determine the extent to which DTW could account for vegetation patterns in the study area.

METHODS

Study Site

Owens Valley lies on the western edge of the Great Basin in eastern California at an elevation of approximately 1200 m above mean sea level. The Sierra Nevada borders the valley on the west, and the White and Inyo Mountains flank its eastern side. Owens Valley summers are hot and dry; winters are cold, and more than three-quarters of average annual precipitation falls during the October to March cold period. Although the climate is arid, with average annual precipitation of 130 mm, abundant water from Sierran snowmelt flows into Owens Valley and annually recharges shallow groundwater aquifers which underlie thousands of hectares of the valley floor (Hollett et al. 1991). As a result, valley floor vegetation is dominated by phreatophytic plant species assembled in alkali meadow and sink habitats (City of Los Angeles and County of Inyo 1991; Howald 2000). The growing season for alkali meadow species in Owens Valley commences in late March (first of spring), reaches a peak in late June when leaves and stems are fully grown, then enters winter dormancy in early October (Sorenson et al. 1991).

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Alkali meadow vegetation is characterized as groundwater dependent because its estimated actual evapotranspiration exceeds annual precipitation (City of Los Angeles and County of Inyo 1991). Under the classification of groundwater-dependent ecosystems by Eamus et al. (2006), alkali meadow habitat falls under the "phreatophytic" category, because groundwater is not regularly expressed on the ground surface. In Owens Valley, large expanses of alkali meadow occur at the toes of Sierran alluvial fans located several miles from open water or Owens River, and the study site is in such a setting.

Most alkali meadow habitat in Owens Valley is on land owned by the City of Los Angeles and is managed for grazing and water export to Los Angeles by the Los Angeles Department of Water and Power. In the mid 1980's, "parcels" of relatively homogeneous vegetation in Los Angeles' holdings were delimited, mapped, and inventoried for species composition and cover. Groundwater levels and vegetation cover and composition on selected parcels have been regularly monitored since 1991. The study site (Fig. 1), located approximately 12 km north of the town of Independence, consists of two adjoining parcels classified in the 1980's as alkali meadow, a classification consistent with Lee's (1912) "grassland" classification made over 70 yr before. Both study site parcels were dominated before the fire by two native phreatophytic grasses *S. airoides* and *D. spicata*, and, in places, by the encroaching shrubs *Artemisia tridentata*, *Atriplex lentiformis* subsp. *torreyi*, and/or *Chrysothamnus nauseosus*. Historically, livestock grazing had occurred throughout the study area (typically from October through May), including during spring 2007. After the July 2007 fire, livestock were excluded from the study area for the remainder of the 2007 growing season.

Substrate of the study site is a combination of ancient beach, bar, or river channel sediments. These deposits lie between alluvial fan deposits upslope to the west and fluvio/lacustrine deposits of the valley floor downslope to the east (Hollett et al. 1991). Soils are moderately- to poorly-drained loams (USDA Natural Resources Conservation Service 2002).

Vegetation Sampling

Inyo County Water Department (ICWD) monitors vegetation composition and cover each summer along randomly-located 50-m transects in selected parcels. ICWD uses the point-intercept technique (Bonham 1989) to determine species composition of the top canopy layer at 0.5-m intervals along the transect. The endpoints of these transects are not permanently marked, but the starting location is recorded with a GPS unit, and its randomly-generated compass bearing is recorded. Two weeks before the Inyo Complex fire, ICWD read point-intercept transects at 48 random locations throughout the two parcels comprising the study area (Fig. 1).

We conducted visual reconnaissance of the burned area several times, starting one week after the fire. Eight weeks after the fire, August 30–September 6, 2007, we used GPS and compass bearings to approximately relocate then re-sample the 48 pre-fire random transect locations in the study area. Twenty were in burned areas and 24 in un-burnt areas. Four of the 48 transects were not sampled because they crossed the burn boundary. To increase the size and spatial extent of post-fire sampling, we randomly selected 22 additional transects throughout the study site. Altogether, we obtained data from 37 transects in the burned area and 29 from the unburned "control" area after the fire (Fig. 1). We employed the same point-intercept method used before the fire to measure species composition and estimate top layer canopy cover. We also noted the most advanced phenology of each species sampled along each transect in the burned area. Phenology was not recorded along pre-fire transects nor along transects in the unburned control area.

Precipitation and Water Table Data

ICWD maintains a precipitation gauge in the study area, and its precipitation totaled 31 mm for the period October 1, 2006–April 30, 2007. No precipitation was recorded from April 17, 2007, until August 28–30, when 3 mm were recorded. Average precipitation for the ICWD gauge period of record (1993–2006) was 160 mm.